DOCUMENTED BRIEFING

RAND

Analytic Support to the Defense Science Board

Tactics and Technology for 21st Century Military Superiority

John Matsumura, Randall Steeb,
Thomas Herbert, Mark Lees,
Scot Eisenhard, Angela Stich

Arroyo Center

The research described in this report was sponsored by the United States Army, Contract No. DASW01-96-C-0004.

ISBN: 0-8330-2482-5

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Published 1997 by RAND
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1333 H St., N.W., Washington, D.C. 20005-4792
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DB-198-A

PREFACE

This documented briefing summarizes a fast-response (one-month) research effort that directly supported the Defense Science Board Summer Study Task Force on Tactics and Technology for 21st Century Military Superiority. This research examined the effectiveness of small dispersed force concepts, defined by the Defense Science Board, as they might be employed on a future battlefield. RAND, through the Arroyo Center, was one of several organizations to provide analytic support to this study. RAND's primary contribution focused on the higher end of the threat spectrum—small dispersed forces against attacking armor—representative of an early entry phase of a larger conflict. A fairly extensive simulation environment was employed to provide analytic-based assessments. Our work in this area continues to evolve as the research provides new insights and raises new questions. This briefing should be of interest to armed forces decisionmakers, policymakers, and military technologists.

The research was sponsored by the Deputy Assistant Secretary for Research and Technology—Chief Scientist in the Office of the Assistant Secretary of the Army for Research, Development, and Acquisition, and was conducted in the Arroyo Center's Force Development and Technology Program. The Arroyo Center is a federally funded research and development center sponsored by the United States Army.

CONTENTS

SUMMARY

MAKING SMALLER FORCES MORE CAPABLE

The Defense Science Board (DSB) Task Force on Tactics and Technology for 21st Century Military Superiority was formed by the Office of the Secretary of Defense to explore new concepts for making a relatively small and rapidly deployable force capable for accomplishing missions that would otherwise require a large, massed force. As part of the concept development phase of the study, the DSB identified two different means of achieving a capable small dispersed force. The first concept represents an evolutionary change from current small forces, such as the division ready brigade (DRB) of the 82nd Airborne. Here the force is envisioned to remain a small, mostly self-contained unit such as a DRB, but it is given the mission and capability of a larger unit such as a division. This may be accomplished by augmenting many of a DRB's current components with advanced RSTA, C2, and weapon systems, much as envisioned in the Rapid Force Projection Initiative (RFPI) and the U.S. Army's Force XXI concept. The DSB builds on these concepts by emphasizing joint nonorganic or "external" RSTA and fire support system technologies.

The second DSB concept is more revolutionary, removing the notion of an area control by ground forces almost entirely. Here, long-range fires are called by small, virtually independent dismounted teams moving around the region. This concept is close to that espoused in the USMC Sea Dragon proposal. The DSB concept builds on Sea Dragon by extending it to include a larger range of external RSTA and weapons and possibly giving it a more substantial level of team mobility.

While our simulation effort focuses on the first concept, the two have many aspects in common, and some merging of ideas is expected. Both concepts emphasize joint operations and coordination among many geographically remote systems. The common question between both concepts is how much of a ground presence is needed to accomplish the many missions envisioned for the force.

ASSESSING THE SMALL FORCE CONCEPT

Breaking the Concept into Components

Given its many dimensions, assessing the effectiveness of the DSB small force concept can be a complex process. To address this concept, we broke it into its fundamental components and systematically "built up" a base DRB into a notional DSB small force.

The first component examined was improved RSTA. We augmented the base DRB with a COVER-like system (similar to the commander's observation vehicle for elevated reconnaissance), in which scout vehicles are given a small tethered UAV that gives a largely unobstructed overhead view. We then added two RFPI-technology RSTA systems—acoustic sensor arrays and remote sentries. The last RSTA system added was a generic high-altitude UAV with foliage-penetrating SAR and GMTI radar.

The next components to be examined were the external weapons and associated C2 options. Notionally, these could include different forms of ground, air, and naval long-range systems. The impact of two representative weapon systems were examined in conjunction with the three aforementioned levels of RSTA, using standard tactics, techniques, and procedures (TTPs). We also conducted sensitivity analysis to determine whether the effectiveness of these weapons could be improved. Assuming near-perfect intelligence, TTPs were changed, volume of fire was increased, and time-over-target timelines were reduced.

The final component examined was force dispersion. The base DRB force was broken up into battalion-sized units and spread out over an area 5 to 6 times as large as before. This force was attacked with two different levels of enemy artillery preparatory fires.

Scenario Used for the Analysis

Given the limited timeframe for our study, we used a variant of the LANTCOM High-Resolution 33.7, an already-existing scenario, originally developed by TRAC and modified for previous analysis. This scenario puts a partially attrited (forced entry) DRB in a hasty defense against a large armor attack (division minus) in mixed terrain. Perhaps uncharacteristic of the scenarios motivating the DSB vision, there is limited battlespace in this scenario, and thus limited time to conduct the enhanced RSTA and fire support phase of the defensive operation.

RESEARCH INSIGHTS

Our research evolved around answering four main questions. These questions are somewhat sequential in form, and they tend to parallel the analysis plan.

- How do more comprehensive and varied RSTA levels affect DRB performance?
- For the different levels of RSTA, how do advanced external fires affect the battle outcome?
- Given near-perfect RSTA, can external long-range weapons themselves stop an attacking force, or will units need organic capability?
- Will dispersing the force make it more or less vulnerable, and will it still be able to carry out a defensive mission?

Our initial responses to these four questions are provided in the following subsections.

How Did More RSTA Change DRB Performance?

Augmenting the base DRB with a COVER-like system offered the potential for more target acquisitions at range; however, a benefit was seen mostly when the system was kept in stationary, hide positions. Using the COVER-like system on the move in mixed terrain yielded only a few more acquisitions than the base RSTA because the system was not able to maintain standoff *and* acquire targets (i.e., there were too many chance encounters from the attacking Red force). Addition of two types of RFPI unmanned sensors—acoustic arrays and remote sentries—provided considerable improvement in target acquisition. Working in conjunction with the COVER-like system, the two RFPI sensors could acquire deep targets nearly as well as close ones. Finally, the addition of a generic high-altitude endurance UAV using GMTI radar had the potential to offer a much more complete picture of the battlefield. However, we note that this type of information (from GMTI) may come with relatively large target location errors and limited ability to discriminate or identify vehicles.[1]

The successive levels of RSTA improvement systematically increased situational awareness, but this alone did not result in improved battle outcomes. The already "dug-in" DRB was postured to handle a multiple-axis Red attack, and any subsequent adjustment to the defensive laydown

[1]Assumes GMTI radar without the benefit of rotation around the targets.

would be expected to yield only limited benefit. More important, increased target acquisitions with improved RSTA did not translate to improved force performance because the long-range weapons currently associated with the base DRB, cannon artillery with conventional rounds, were generally not effective against moving armor.

How Does Advanced External Fire Support Change DRB Performance?

When the above RSTA was accompanied by advanced external fire support, the DRB effectiveness was seen to improve notably. We assessed two different external "area" weapon system options that could be made available to the DRB in the future: an air-delivered standoff weapon with relatively small-footprint submunitions, and a missile-delivered weapon with large-footprint submunitions. Without any RSTA improvements to the DRB, the relatively sparse, incomplete intelligence generally did not allow for such external weapons usage (assuming standard TTP guidance). *However, as RSTA was added, target opportunities rose, resulting in deep enemy attrition. Generally, as more RSTA was added, more engagement opportunities appeared and more weapons were fired, resulting in a greater percentage of enemy vehicles being attrited before closing to the direct fire battle. Consequently, the direct fire battle intensity decreased, and overall force effectiveness improved (as expressed in loss-exchange-ratio). This effect was more evident for the large-footprint submunition than for the small-footprint one.*[2]

Can External RSTA and Fire Support Do It All?

To address this question, we performed a parametric analysis that systematically "improved" the application of the external fire support. Assuming the best RSTA case (near-perfect intelligence), we decreased the time to target to the point where weapons were delivered instantaneously. We also increased the volume of fire up to an order of magnitude higher than what standard TTPs might suggest. We next examined the effect of imposing battle damage assessment (BDA) between subsequent missions (i.e., are the weapons ripple fired, or is there an intermediate step to assess the effect before follow-on fires are committed?).

Generally, we found that shorter timelines led to higher overall weapon effectiveness, but this occurred only up to a point. Both weapons

[2]Both weapon systems were assumed to originate from some distance away. Platforms that loiter or weapon systems that can be updated while in flight will probably yield different results.

considered had some ability to compensate for target location error (TLE) and target movement error, and so both could be used effectively with some level of time delay. As expected, the weapon with small-footprint submunitions tended to perform best with very short timelines and when targets were moving predictably. In all other cases, the submunition effectiveness was seen to drop off significantly. In contrast, the large-footprint submunitions were generally much more forgiving. That is, reducing time over target from 20 minutes to 10 minutes produced some improvement; however, shortening the timeline further to zero yielded only minor improvements over the 10-minute time. This effect can be attributed directly to the ability of the footprint to compensate for the time delay.

With regard to volume of fires, for both weapons we observed significant "diminishing marginal returns" effects. That is, as more munitions were committed, the efficiency (kills per weapon fired) decreased, with the last targets becoming the hardest to hit.

We also varied the requirement for BDA. Because these weapons are considered precision weapons, there is normally some BDA imposed after a volley lands and prior to reengaging the same set of targets. (That is, before committing subsequent fires, one should determine the outcome of the current fire mission.) This allows for appropriate scaling of effect for the subsequent volley. For our parametric analysis, we generally assumed optimistic levels of BDA—either it was almost instantaneous after the munitions landed or there was no requirement for BDA whatsoever. No requirement for BDA led to rounds being "ripple fired" at a set of targets.

Interestingly enough, even with the best of all cases (near-perfect intelligence, instantaneous time over target, high volume of fires, and no requirement for BDA), not all targets were killed. *This suggests that at least some level of organic weapons is needed to achieve the objective (e.g., to protect the airfield).*

What Happens with Dispersion of the Force?

We have only started to address the value of dispersion. What we have seen so far suggests that merely dispersing the base DRB will yield mixed effects. On the positive side, the indirect fire battle outcome improves for the DRB because enemy artillery fire becomes much more "diluted" given the larger area it must cover. However, on the negative side, the direct fire battle for the DRB degrades somewhat because its defense occurs around a much longer perimeter, resulting in a reduction of interlocking, mutually supporting fires. This outcome may change, though, with added DRB precision indirect fires, external fires, or more effective dispersion into mutually supporting "defensive pockets."

CONCLUSIONS

In general, the DSB concept for enhancing small dispersed forces with external RSTA and weapons offers tremendous potential for improving the outcome of battle. However, we note that the concept relies on many steps to operate effectively—acquiring targets, passing information, assigning weapons, dispensing munitions, performing BDA, and many others. Each of these steps must function well for the concept to succeed.

Up to a point, we found that adding layers of ground-based and overhead RSTA could significantly improve situational awareness and enhance the application of external fires. The situation estimate can seldom be both complete and accurate, though, and different types of sensors contribute different inputs to the overall picture. In those cases where overlap of coverage was present, additional value was still observed in the form of commander confidence in committing rounds.

The notion of "if you can see it, you can kill it" was not demonstrated here. External fire support may exhibit long flyout and cycle times, and may not be able to engage targets as decisively as organic weapons. This can be especially true if the enemy uses deliberate countermeasures, such as dispersion, jamming, or decoys.

In view of such uncertainties, a force equipped with organic firepower appears to be essential, especially so when either an objective must be protected or an area must be denied to the enemy. Although our research does suggest that the amount of organic capability can be reduced given a significant presence of effective external RSTA and fire support, the most attractive and robust solution for enhancing the capability of small forces was a mix between advanced organic systems *and* external systems.

ACKNOWLEDGMENTS

Many people took the time and made the effort to contribute to the development of this quick-response research. To these people, the authors owe a debt of gratitude. At RAND, Dr. Bernard Schweitzer generously provided information on advanced radar technologies, Dr. Eugene Gritton provided high-level information on emerging small force concepts and technologies, and Dr. Paul Davis provided a highly constructive and timely technical review of this document.

Dr. John Parmentola and Dr. Fenner Milton at the Office of the Secretary of the Army for Research, Development, and Acquisition sponsored this research. Dr. Theodore Gold and Dr. Donald Latham, co-chairmen of the Defense Science Board Study on Tactics and Technology for 21st Century Military Superiority, provided high-level direction for this research. Major General Jasper Welch (USAF Ret.) and General David Maddox (USA Ret.), leaders of the simulation support to the Defense Science Board, provided critical guidance throughout the research process.

This work was conducted in the Force Development and Technology Program within the Arroyo Center, under the management of Dr. Kenneth Horn and Mr. James Quinlivan.

The authors alone are responsible for the information contained in this documented briefing.

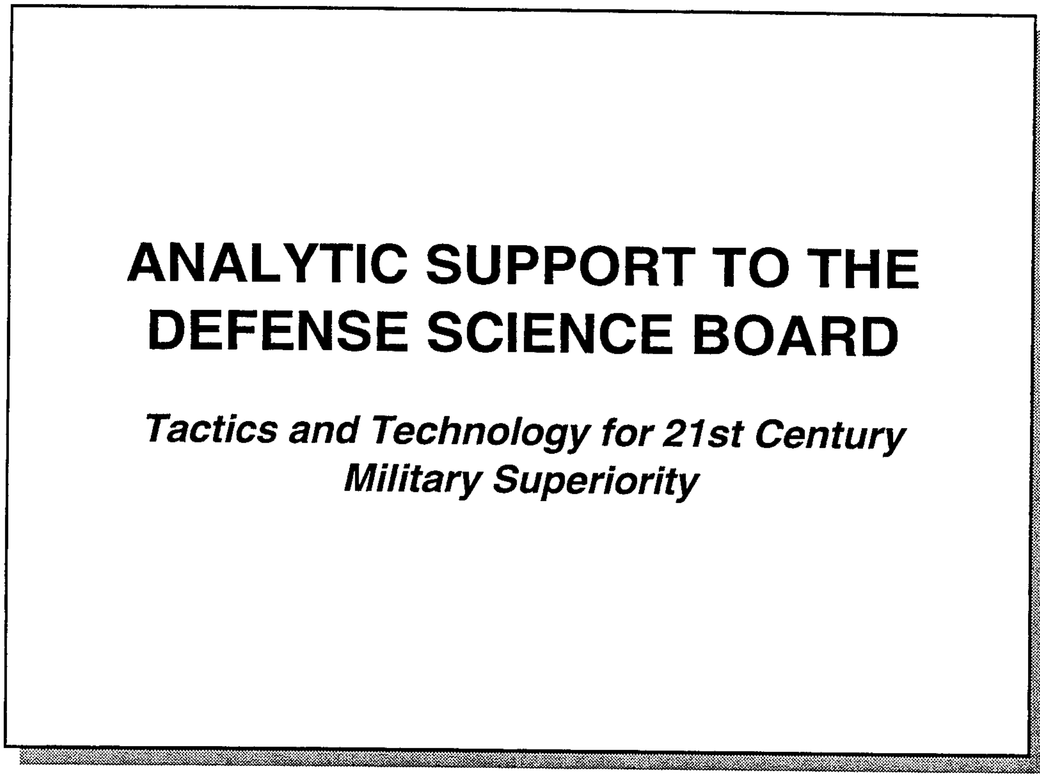
GLOSSARY

ABN	Airborne
ACTD	Advanced Concept Technology Demonstration
AD	Air Defense
AGS	Armor Gun System
APC	Armored Personnel Carrier
ASP	Acoustic Sensor Program
ATACMS	Army Tactical Missile System
ATGM	Anti-Tank Guided Missile
BDA	Battle Damage Assessment
C2	Command and Control
CAGIS	Cartographic Analysis Geographic Information System
COVER	Commander's Observation Vehicle for Elevated Reconnaissance
CM	Countermeasure
CR	Close Range
DPICM	Dual Purpose Improved Conventional Munition
DRB	Division Ready Brigade
DSB	Defense Science Board
EFOG-M	Enhanced Fiber Optic Guided Missile
FLIR	Forward-Looking Infrared
FO	Forward Observer
GLLD	Ground Level Laser Designator
GMTI	Ground Moving Target Indicator

HAE	High Altitude Endurance
HE	High Explosive
HIMARS	High Mobility Artillery Rocket System
HMMWV	High Mobility Multi-Purpose Wheeled Vehicle
ICM	Improved Conventional Munition
IFF	Identification Friend or Foe
IFV	Infantry Fighting Vehicle
IR	Infrared
JSOW	Joint Standoff Weapon
LER	Loss Exchange Ratio
LOS	Line-of-Sight
MADAM	Model to Assess Damage to Armor with Munitions
MLRS	Multiple Launch Rocket System
MOUT	Military Operations on Urban Terrain
MRL	Multiple Rocket Launcher
MTI	Moving Target Indicator
NLOS	Non-Line-of-Sight
NVEOL	Night Vision Electro-Optical Laboratory
PGMM	Precision Guided Mortar Munition
RAP	Rocket-Assisted Projectile
RFPI	Rapid Force Projection Initiative
RJARS	RAND's Jamming Aircraft and Radar Simulation
RSTA	Reconnaissance, Surveillance, and Target Acquisition
RTAM	RAND's Target Acquisition Model
SAR	Synthetic Aperture Radar

SEMINT	Seamless Model Integration
SOF	Special Operations Forces
SPH	Self-Propelled Howitzer
TACAIR	Tactical Aircraft
TLE	Target Location Error
TOC	Tactical Operations Center
TOW	Tube-Launched, Optically-Tracked, Wire-Guided (Missile)
TOT	Time Over Target
TRADOC	Training and Doctrine Command
TRAC	TRADOC Analysis Center
TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
USMC	United States Marine Corps

1. INTRODUCTION



In July 1996, RAND was asked to provide a quick-response analysis to the Defense Science Board (DSB) on the military utility of options for small, dispersed forces. This documented briefing summarizes our examination and simulation of selected systems (reconnaissance, surveillance, target acquisition, command and control, and weapons systems) and new tactics and doctrine.

Project Objective

- **Explore the potential contributions of small dispersed force concepts on a future battlefield**
  - **Early entry phase of major contingency**
  - **U.S. defends against attacking armor**

The primary objective of the work is to use high-resolution simulation to explore and quantify the potential contributions of light force concepts in a specific set of circumstances—the early entry phase of a major contingency, when only light forces are in place. These light forces are required to defend a high-value area against a large attacking armor force.

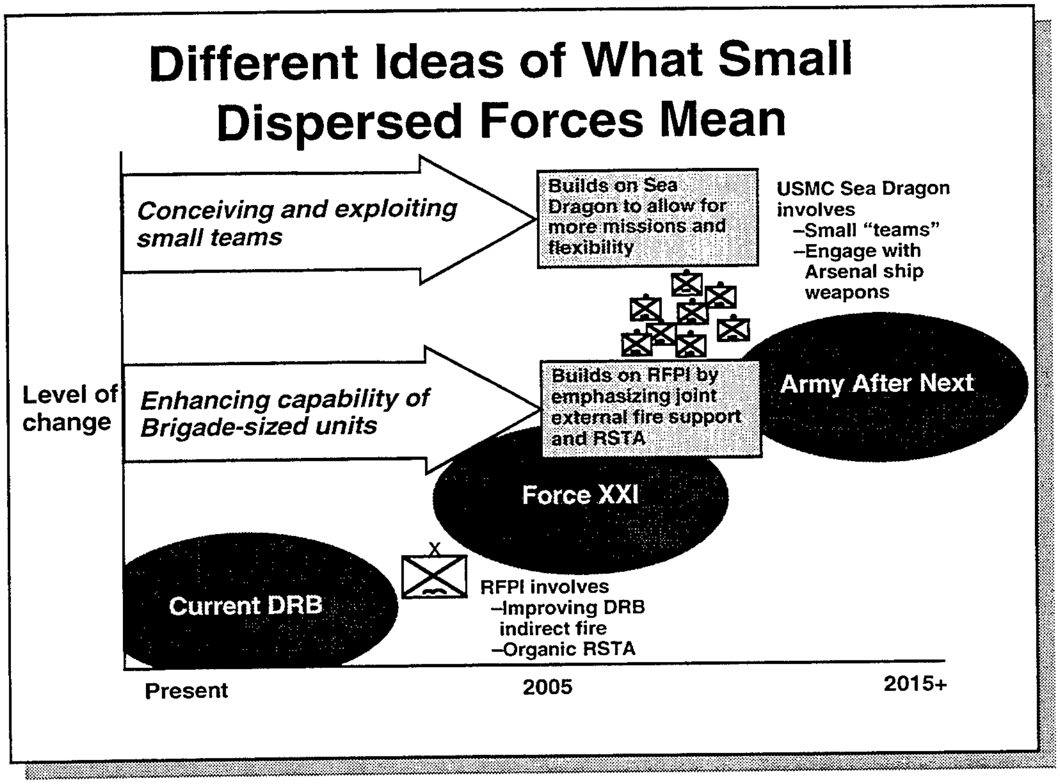
Other circumstances of interest to the DSB, such as use of small dispersed forces performing in infantry operations, MOUT, and low-intensity conflict, are being examined by other simulation and modeling groups. Our work should have some applicability to these other areas, but our emphasis is on the anti-armor battle in a major contingency.

Small Dispersed Force Concept May Involve Dramatic Changes

Conventional force	Small dispersed force	Possible solutions
Overwhelming force	Minimize force, casualties	- Standoff, stealth, unmanned systems
Massed troops	Dispersed troops	- Improved C2 network - New logistics concept
Direct fire battle	NLOS battle	- Rapid, indirect fires
Massed firepower	Precision fires	- Efficient, discriminating weapons
Hold ground	Defend/deny ground	- Detect, deliver, scoot
Close and destroy	Destroy at standoff	- RSTA/C2/long-range fires
Threat distinct	Threat intermingled w/friendly forces	- Robust IFF systems - Precision fires

The small dispersed force concept can be quite revolutionary in form, with many implications for the conduct of future warfare. For example, traditional or conventional conflicts, including Desert Storm, have emphasized positional warfare in which massed forces and firepower have been used to take and hold ground using primarily direct fire weapons. Use of small dispersed forces may change this by minimizing the presence and vulnerability of U.S. troops, and by enabling small forces to take on the missions of much larger units. These forces will rely on non-line-of-sight systems to destroy much of the enemy force and avoid the high-attrition line-of-sight battle. While the light dispersed forces will not be as able to hold ground as conventional heavy forces, they should still be able to inflict substantial losses on the enemy and deny him the ability to maneuver, occupy ground, or otherwise affect Blue operations.

The types of systems and technologies needed to achieve these goals include deep, survivable RSTA systems, agile and robust C2 architectures, and precision, discriminating weapon systems. Some very sophisticated technologies, such as stealth, robotics, and automated IFF, may also be required for key missions.



The DSB has identified two different means of achieving a capable small dispersed force. The first is an evolutionary change from current small forces such as the division ready brigade (DRB) of the 82nd Airborne. Here the force remains as a small, mostly self-contained unit, but it is given the capability and mission of a larger unit. This is done by replacing many of the current components with advanced RSTA, C2, and weapon systems, much as is envisioned in the Rapid Force Projection Initiative (RFPI). The DSB concept builds on the RFPI plan by emphasizing long-range, joint external RSTA and fire support.

The second DSB concept is more revolutionary, removing the notion of an area control by ground forces almost entirely. Here, long-range fires are called by small, virtually independent dismounted teams moving around the region. This concept is close to that espoused in the USMC Sea Dragon proposal. The DSB concept builds on Sea Dragon by extending it to include a larger range of external RSTA and weapons, and possibly giving it a more substantial level of team mobility.

Although our simulation effort focuses on the first concept, the two directions have many aspects in common, and some merging of ideas is expected. Both concepts emphasize joint operations and coordination among many geographically remote systems. The main question is how much of a ground presence is needed to accomplish the many missions envisioned for the force.

Key Research Questions

How might DSB small force concept improve brigade-sized unit performance?

- **What kinds of opportunities do different *RSTA* concepts provide?**
- **How do different levels of *target acquisition* affect long-range weapon performance?**
- **Given best RSTA, can *external long-range weapons* defeat armor attack, or will units need organic capability?**
- **How does *dispersion* affect the indirect and direct fire engagement dynamics?**

There are four main research questions we attempt to answer in our work on enhancing the capability of brigade-sized units. These questions are somewhat sequential in form, and they tend to focus on one issue at a time. First, how do more comprehensive and varied RSTA levels impact situation awareness and target acquisition? Second, for a given type of precision long-range weapon, how do different levels of target acquisition quality affect battle outcomes? Third, we ask a force composition question—given near-perfect RSTA from a variety of sources, are there circumstances in which external long-range weapons can themselves stop an attacking force, or will units need organic direct and indirect fire capabilities? In effect, can small semi-independent teams and external weapons alone do the job? The last question focuses on the effect of spreading out the Blue light force to cover more area—will the force be more or less vulnerable, and will it be able to better carry out a defensive mission?

Mission and Scenario Examined Is Only a Starting Point for Answering Questions

- Specific conditions may not permit generalizations
  - Focus on engagement of moving armor
  - Relatively small area of battlespace available to conduct long-range attack operation
- "Benefit of doubt" given to technology
  - Assume near-perfect communication connectivity
  - Future RSTA and weapon systems perform as expected

To begin to answer these research questions, we are using a specific scenario, with Red armor attacking a Blue light force in a hasty defense. We consider this scenario to be a good starting point, as it addresses many key issues for the light force concepts, such as surveillance and targeting of mobile and stationary units in several different formations and in several types of terrain. Other scenarios should also be examined to provide more complete insights about the force options, and the concepts themselves should be evaluated in degraded conditions. For example, blocked communications, unreliable and flawed RSTA inputs, and stressing environmental and battlefield conditions should all be represented in future work.

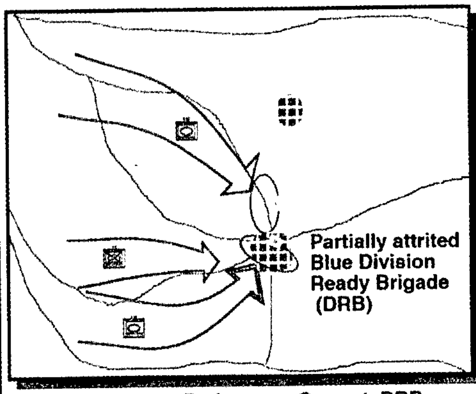
2. BACKGROUND

Outline

- Background
- Research plan
- Findings
- Conclusions

The annotated briefing is divided into four parts, with the great majority of attention given to the findings section. The first section describes the scenario and methodology used in our work.

LANTCOM: Light Infantry in Hasty Defense Against Heavy Division(-) in Mixed Terrain



1998 Force	Red		Current DRB
Tank	131	T-72S	4 AGS
ATGM	0		24 Javelin
APC/IFV	143	BMP	34 HMMWV-TOW
Rocket artillery	6	MRL	0
Cannon artillery	12	2S3†	26 105/155 (towed)
Helicopters	6	Havoc	6 Apache
Air defense	40	2S6	6 Stinger teams

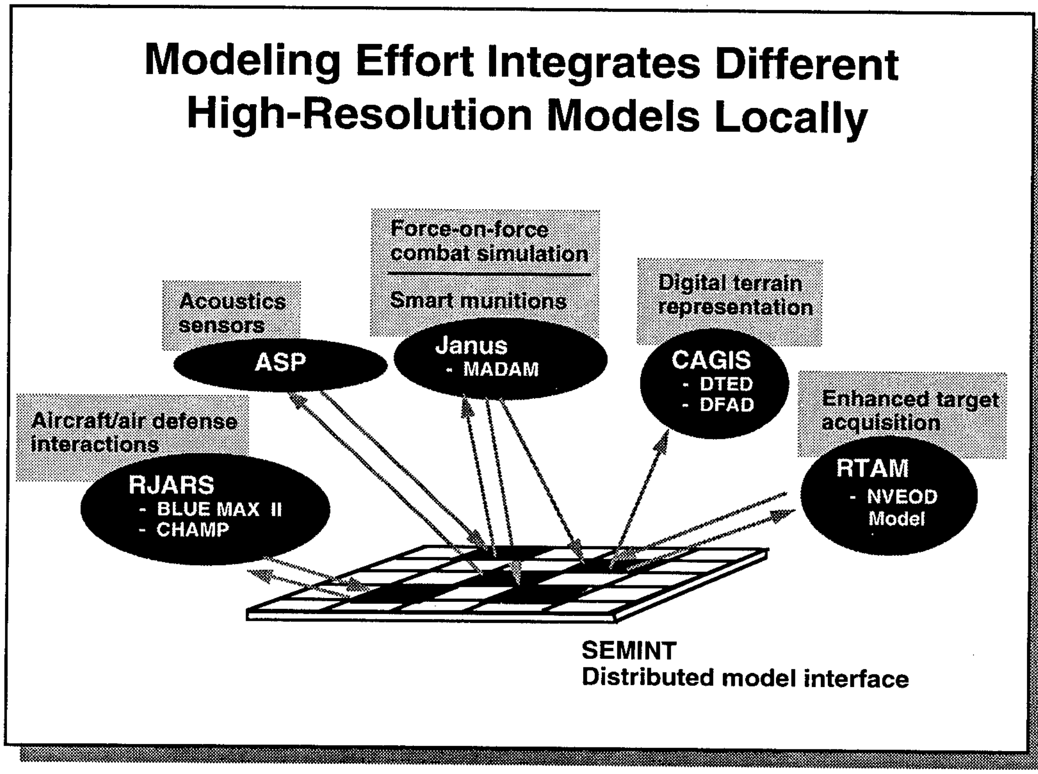
†152mm SPH.

Simulation screen image (modified TRAC HRS 33.7)

The scenario we used for the analysis is a high-stress variation of the TRAC High Resolution Scenario 33.7 in LANTCOM. In this scenario, a partially attrited Blue DRB (following forced entry) faces a substantially larger Red force, a division (-) attacking along three primary avenues of approach. The Red force contains some sophisticated weapons, including: T-72S with AT-11 (fire on move) missiles, BMP-2s and BTR-60s with AT/P-6 missiles, self-propelled 120mm MRLs and 152mm (2S3) howitzers, which are considered to be medium to hard targets, and mobile air defense units (2S6) with radar track 30mm guns and (SA-19) missiles. Red does not have sophisticated RSTA and must rely on commander FLIRs and visual recognition for the direct fire engagements.

The Blue force objective is to hold the key strategic point (an airstrip), until heavy reinforcements, now en route, can arrive. The Red objective is to destroy the Blue force as fast as possible before reinforcements can engage. Preparatory fires from Red self-propelled artillery—firing improved conventional munitions (ICM) and high explosive (HE) rounds—support the deliberate Red armor attack.

The partially-attrited DRB is assumed to have enough time to set up a defensive position, complete with extensive ground-based RSTA—prior to the Red attack. The simulation screen image above shows the main body of the Blue force positioned in the high ground around a town. Forward of this (to the west) are RSTA systems spread over the likely Red areas of advance. The area shown is approximately 60 by 60 kilometers.

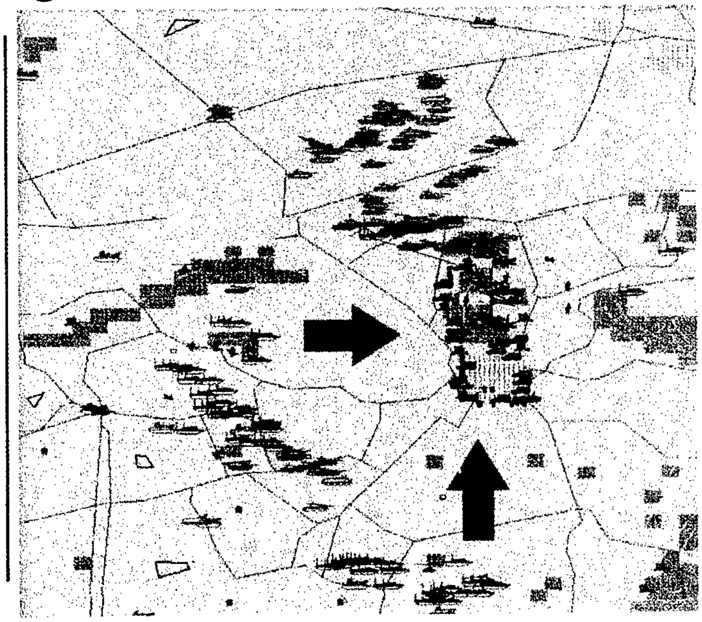


Over the last half-dozen years, we have developed a locally distributed interactive simulation system to support analytical studies on advanced land combat. Although the work is usually conducted entirely within RAND, it involves connecting a number of separate models and simulations as shown above. Janus provides the overall force-on-force ground combat context, where the RAND version can represent up to 1,200 distinct entities on a side.

Generally, the other models and simulations allow us to examine other combat dynamics in greater detail or fidelity than available in Janus. RTAM and CAGIS, for example, allow us to represent acquisition of reduced signature vehicles on the battlefield. RJARS models the detection, tracking, flyout and fusing of air defense missiles. MADAM and CAGIS simulate the effects of smart munitions, including multiple hits, hulks, unreliable submunitions, etc. ASP models acoustic sensing by such systems as unattended ground sensors and smart mines. SEMINT, finally, allows all of these simulations to communicate during a simulation. The integrated set of models can be run interactively (with Red and Blue gamers), or the system can be run in batch mode with plans and behaviors input beforehand.

Simulation Shows Base DRB Does Not Survive Against Large Armor Force Attack

- **Virtually all engagements occur in the direct fire (LOS) battle**
- **Blue direct fire systems achieve good LER≈3 to 1**
- **However, Red massed attack eventually overwhelms Blue**
- **Primary direct fire vehicles are attrited**
- **Then, dismounts and towed artillery become vulnerable**



Red force overruns Blue defense

Simulation in the LANTCOM scenario shows that the base DRB is unable to attrit the attacking Red force at range, because its only indirect fire assets—towed 105 and 155mm howitzers firing DPICM and HE—are relatively ineffective against moving armor. Only 3% of kills by Blue are attributable to artillery, while 30% of kills by Red are from artillery firing (preparatory fires) on the fixed Blue positions.

The Apaches provide some extended-close (out to 15 km or so) lethal fire, but this is not significant enough to halt the attack. The battle moves quickly to a ground-based direct fire engagement, which favors the defenders initially, with an observed 3–4:1 loss exchange ratio (LER).[1] However, Red's superior numbers, heavier firepower (including a fire-on-the-move missile), and greater armor protection soon overwhelm Blue. In particular, Red directs massed fires on the Blue vehicles that exhibit firing signatures. Red then penetrates the defensive lines and defeats Blue in detail. We typically examine the simulation outcome at 58 minutes into the battle, because this is the time when Red first breaches Blue's defense.

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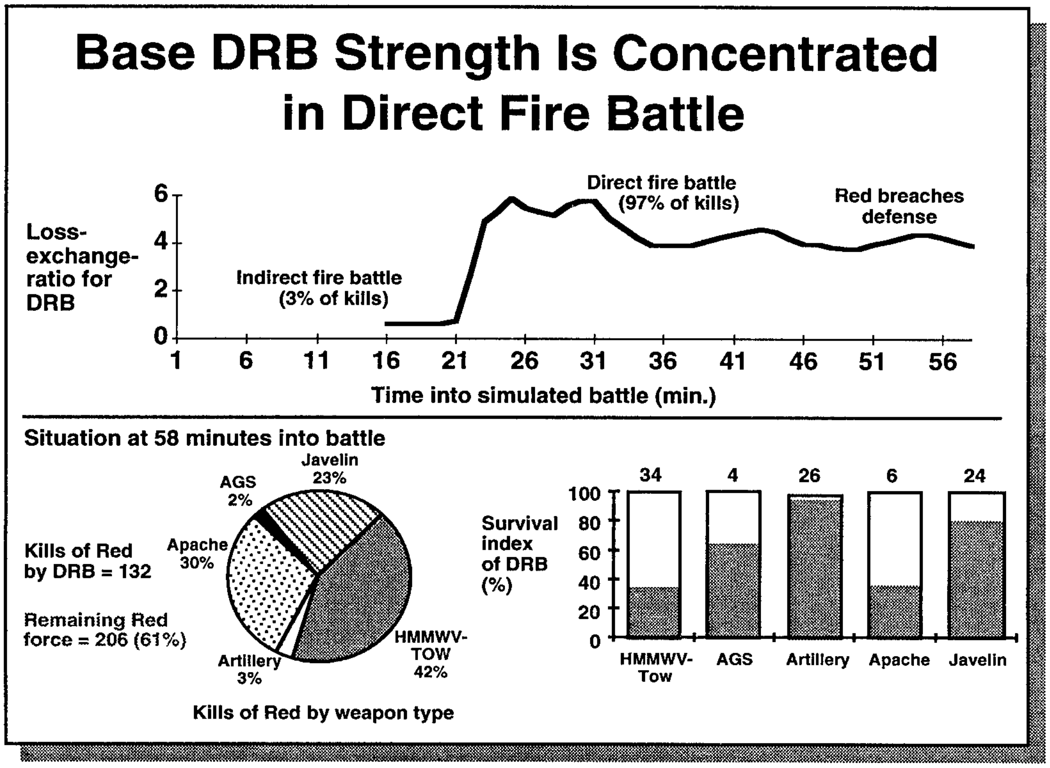
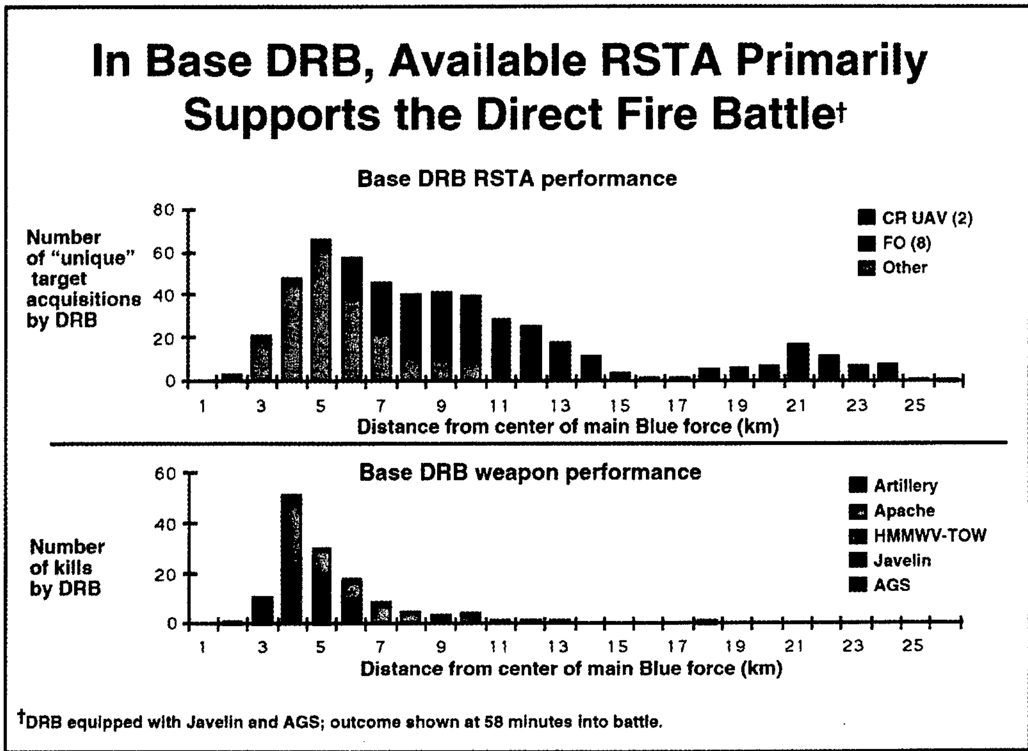
[1] Because of the initial force ratio of about 6:1 in favor of Red, and the heavy versus light composition of the two forces, we observed that a decisive win for Blue required a loss exchange ratio on the order of 10:1 or better.



The 58-minute snapshot look on the previous slide provided only a limited picture of the dynamics and outcome of the simulated battle. In the LANTCOM scenario, the base Blue DRB shows a very low LER for the first twenty minutes of battle. In effect, it is losing the indirect fire battle against the overmatching Red long-range artillery. The LER increases as the engagement moves into the direct fire phase, but Blue is still penetrated and overrun. Most of Blue's kills of Red are due to Apache, HMMWV-TOW, and Javelin. Survival of Blue's mobile systems—HMMWV-TOW, AGS, and Apache—is very limited, dropping to about 50% at the stopping point.



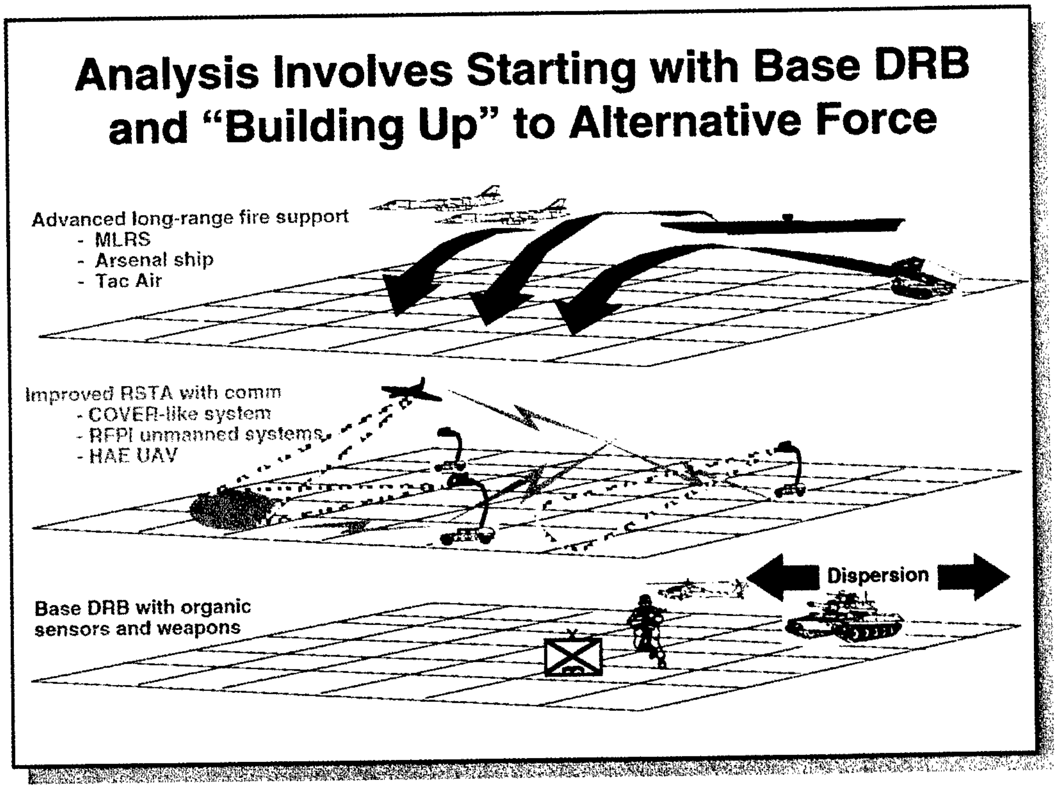
These figures show that Blue target acquisition primarily supported the direct fire battle, because the indirect fire systems—105 and 155 mm towed howitzers—were able to kill only a few Red armored systems. Most of the Blue direct fire systems were self-cued anyway, as they directed their fires at targets they themselves identified. The deeper acquisitions, at 18–24 km, were provided by two tactical UAVs flying at approximately 1,000 meters over the battlefield. These close range UAVs were flown to maintain some level of standoff from the attacking force (no overflight) and, thus, were assumed to be survivable in this analysis.

3. RESEARCH PLAN

Outline

- Background
- **Research plan**
- Findings
- Conclusions

We now describe the research plan for investigating the potential benefits of improved RSTA, external fire support, and dispersion to the DRB force.



Our analysis was designed to examine different parts of the DSB concept in sequential form, building up a picture of the significant issues.

The first series of runs examined RSTA performance. We augmented the base DRB with a COVER-like system, in which scout vehicles are given a small tethered UAV that gives a largely unobstructed overhead view. We then added two RFPI systems—acoustic sensor arrays and remote sentries. The last RSTA system added was a standoff high-altitude (based loosely on Tier II+) UAV with foliage-penetrating SAR and MTI radar.

The second set of runs examined application of joint external weapons options, including ground, air, and naval long-range systems. These last excursions were made under conditions of near-perfect RSTA.

The final set of runs looked at force dispersion. The base DRB force was spread out over an area 5 to 6 times as large as before. This force was attacked with two different levels of enemy artillery preparatory fires.

4. FINDINGS

Outline

- Background
- Research plan
- Findings
- Conclusions

Next we summarize our results.

Findings

- **What kinds of opportunities do different RSTA concepts provide?**
- How do different levels of target acquisition affect long-range weapon performance?
- Given best RSTA, can external long-range weapons defeat armor attack, or will units need organic capability?
- How does dispersion affect indirect and direct fire engagement dynamics?

- **Ground-based RSTA gives accurate but limited coverage, overhead systems complete the picture**

First, we look at the level of situational awareness provided by several different possible combinations of future RSTA systems. The systems were found to be complementary in nature, giving a good overall picture of Red position, status, and composition.

RSTA Systems Examined Have Very Different Characteristics

- **FO—2-man team deploy on foot; optical sensor with 4 km max range with GLLD**
- **UAV—employ with standoff tactics at 1000 meter alt.; equipped with advanced FLIR 6 km max range**

- **COVER-like—hovering UAV tethered to HMMWV; equipped with either 3 or 6 km max range FLIR**
- **Acoustic sensor—8 microphone, non-LOS system; nominal 3 km range against loud target (e.g., tank)**
- **Remote sentry—unattended ground sensor with mast-mounted FLIR cued by acoustics; 3 km max range on FLIR**
- **Generic HAE UAV—GMTI radar with P_A= 0.9 in open, P_A = 0.45 in intermittent foliage (not explicitly modeled)**

The base types of RSTA systems currently in the DRB are shown at the top of the chart, and future additions contemplated for this study are shown below the line.

The base DRB has forward observer teams with laser rangefinder and designators, and tactical UAVs with stabilized FLIRs.

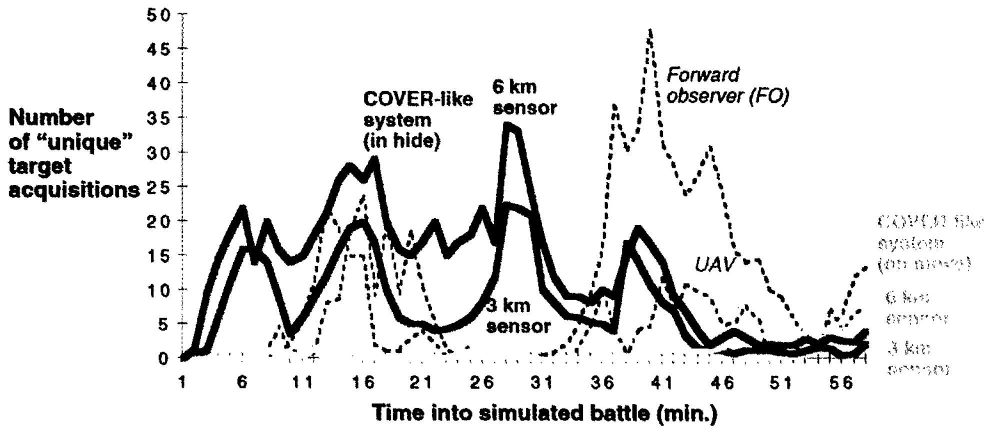
The future systems include COVER (a small tethered UAV 200 feet above its associated scout vehicle), arrays of eight microphone acoustic sensors, acoustic/imaging remote sentry, and high-altitude endurance UAVs. All except HAE UAV are modeled explicitly. Acoustic phenomena such as non-LOS sensing, triangulation among sensors, and target loudness levels are all represented in the model. Imaging system sensitivity is similarly captured, using modifications of the NVEOL algorithms. The HAE UAV with ground moving target indicator (GMTI) radar, on the other hand, is represented statistically. A standoff system should be able to perform GMTI across the entire region quickly. In foliage penetration mode, it should be able to penetrate brush easily and trees with some difficulty. The resulting picture should show most moving targets, but with limited location accuracy and type discrimination.

We Augmented FOs with COVER-Like System in LANTCOM Scenario

- **Initial parameters examined**
  - **Range of sensor (3 km vs. 6 km FLIR)**
  - **Tactics (on-the-move vs. stationary)**
- **Results from simulation**
  - **System operating with on-the-move tactics did not survive or provided minimal acquisitions**
    - **Multi-axis target attack did not allow for comprehensive acquisition (w/limited FOV sensor)**
    - **Speed of attack did not allow system to maintain safe standoff**
  - **In stationary hide positions, 6 km FLIR provided about 40% more acquisitions than 3 km FLIR**

We performed several excursions to determine the effectiveness of COVER, a HMMWV-based scout vehicle with a tethered UAV (since the COVER system is still not yet fully defined, we refer to it as a "COVER-like" system in this report). The UAV was given a basic FLIR (3 km max range against ground targets) and a very good FLIR (6 km max range). The scout platform itself, a HMMWV, was commanded to move in some excursions (maintain standoff with the enemy and return to the DRB main body) and to remain stationary and be bypassed in other excursions. We found that movement compromised performance heavily, even with the very good sensor. Movement typically resulted in platform losses, and any attempt to maintain standoff with Red reduced the number of acquisitions by the COVER-like system to almost zero. A stationary set of scout/COVER-like systems in forested hide positions, on the other hand, provided substantial numbers of detections, especially with the longer-range sensor.

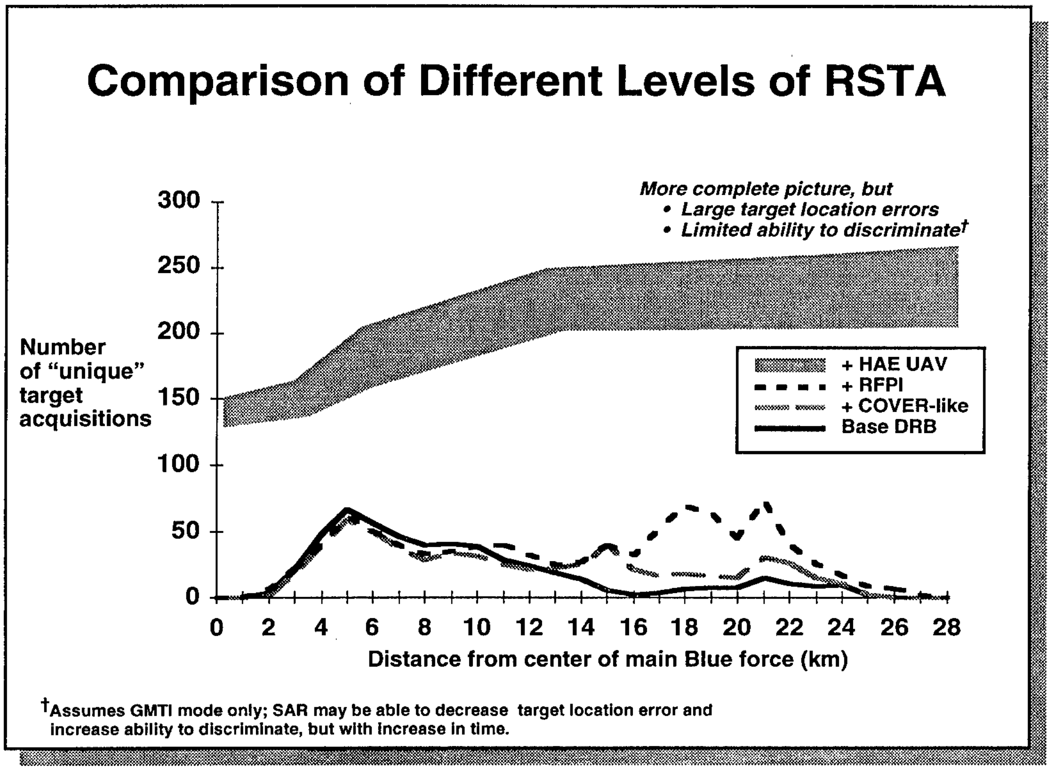
Addition of COVER-Like System Provided Utility Only When in Hide Positions



The chart summarizes the four COVER-like conditions (good and basic FLIR, moving and stationary HMMWV) just described. For comparison, the dotted lines show the detections by UAVs and FOs. In all cases, unique detections are shown over time, starting with initiation of the scenario on the left and stoppage at 58 minutes on the right.

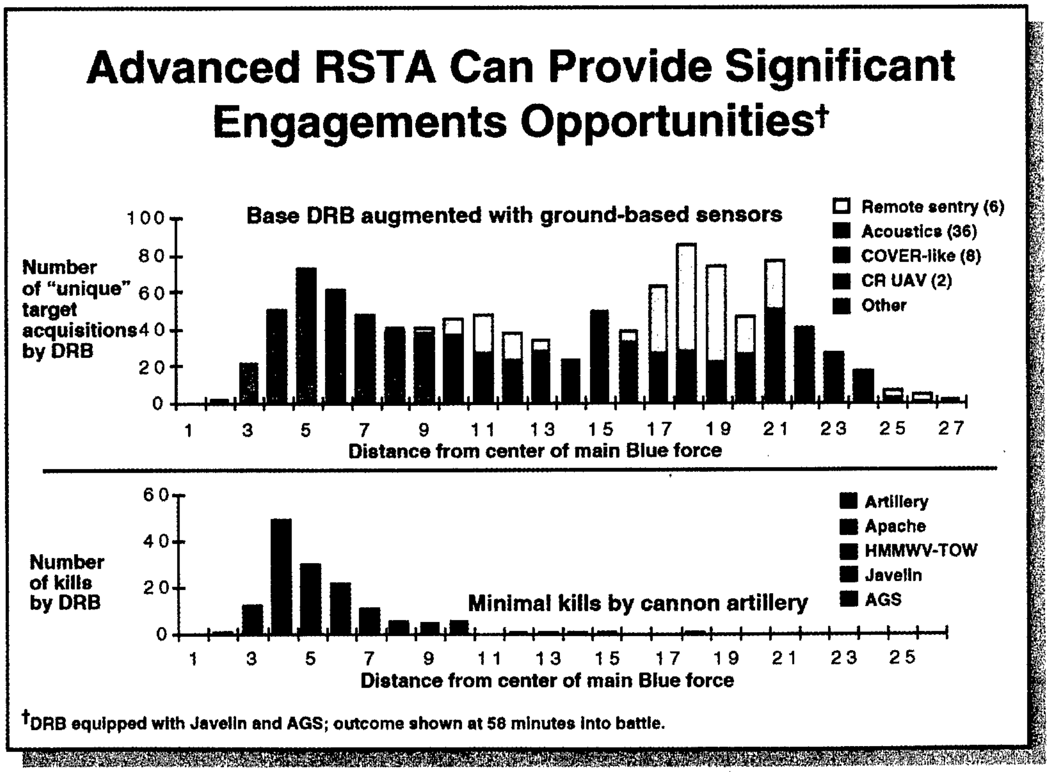
Detections by moving COVER-like systems are minimal, as shown by the lines near the x-axis. Only when the few survivors rejoin the force are there a few detections.

Detections by stationary COVER-like systems in hide are a major contribution to Blue situation awareness, and occur over a wide spectrum of times in the scenario.



This chart shows by range a comparison of RSTA detection completeness as we add each system. The base DRB systems (FO, UAV, direct fire platforms) are shown by the solid line, with many detections at 14 km or closer. Addition of the COVER-like systems (in hide positions) provide more detections at depth, and the RFPI unattended sensors further fill out the long-range detections. High-altitude UAV gives a picture of virtually all enemy systems.

The quality of detection also varies with system. Basic DRB systems are typically eyes on the target and tend to be high-accuracy, high-confidence detections. The other systems tend to have less accuracy and discrimination of target type, with HAE UAV in its MTI mode just providing indications of unit size, speed, and general area. SAR mode imaging of the targets can be done by the UAV with high resolution and good location accuracy, but this takes significantly more time than MTI and covers much smaller areas (returns have to be integrated over a several-degree rotation angle around the target).



Advanced RSTA, as exemplified here by a force with COVER-like systems and RFPI unattended sensors, provides detection over much of the battlefield, but the organic indirect fire weapons associated with the base DRB are unable to capitalize on the information. The number of kills is essentially the same as with the base RSTA. We also noted few opportunities to effectively reposition the Blue force with the added RSTA contacts.

Findings

- What kinds of opportunities do different RSTA concepts provide?
- **How do different levels of target acquisition affect long-range weapon performance?**
- Given best RSTA, can external long-range weapons defeat armor attack, or will units need organic capability?
- How does dispersion affect indirect and direct fire engagement dynamics?

- Ground-based RSTA gives accurate but limited coverage, overhead systems complete the picture
- **More RSTA resulted in better long-range weapon effectiveness, but only up to a point**

We next introduced an exemplary weapon to the force (a long-range missile, with large-footprint submunitions) to determine the effects of different levels of RSTA combined with "external" fire support. Up to a point, additional RSTA had a strong impact on performance with this remotely-located, long-range weapon.

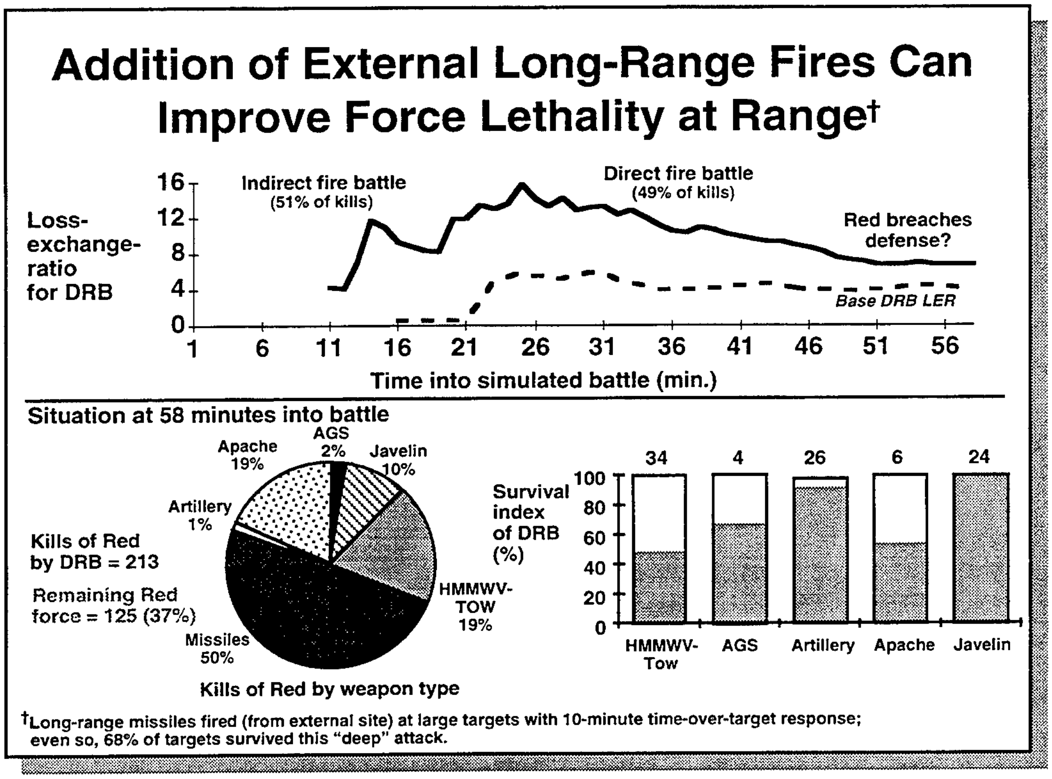
Up to a Point, More RSTA Resulted in Higher Force Effectiveness

DRB force	Number of missiles fired	Number of missile kills	Number of direct fire kills	Loss exchange ratio
Base DRB RSTA	N/A	N/A	136	4.2
COVER-like system	18	58	126	5.0
Plus RFPI ground sensors	34	106	107	6.8
Plus HAE UAV	36	119	106	6.8

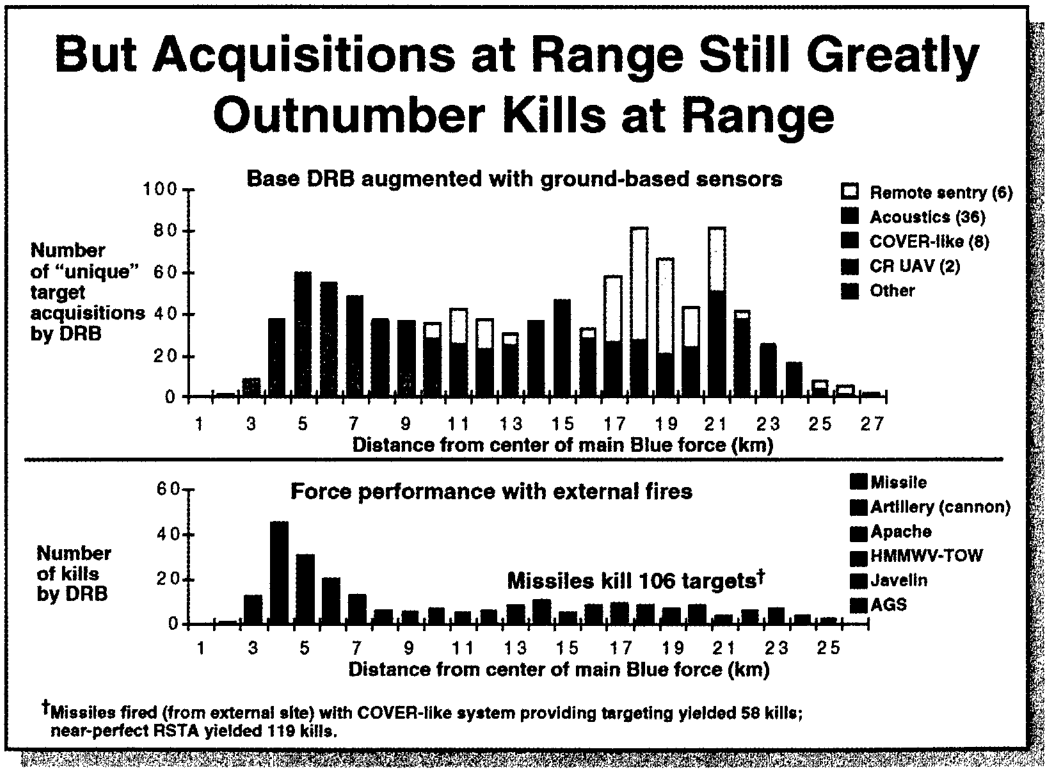
†Missiles with large-footprint submunition fired at large targets with 10 minute time-over-target response.

We assumed that the time-on-target (time from detection of the target to munitions arriving at the predicted point) was 10 minutes for the long-range weapon. Standard TTPs for this weapon required company-sized or battalion-sized targets to be present, because the weapon dispensed many individually targeted smart submunitions. In our simulation runs, an active duty artillery officer calculated lead distances and targeted the munitions as targets presented themselves on the Janus simulation screen.

The chart shows that with base DRB RSTA (FOs and UAVs), no appropriate target opportunities were seen for the long-range weapon. When the COVER-like system was added, nine aimpoints were selected (fired at with two missiles each). This resulted in 58 kills by the long-range missiles and a reduction of direct fire kills. Further addition of two RFPI RSTA systems (acoustic sensors and remote sentry) roughly doubled the number of aimpoints and kills, as did the full set of RSTA including HAE UAV. The minimal increase with HAE UAV over the RFPI sensor network seemed to be due to decreasing usefulness of further data. Most large targets were seen, and the large-footprint submunition made up for targeting errors induced from partial information. Nonetheless, the more complete information from the HAE UAV was seen to greatly increase the commander's confidence in conducting a fire mission. Interestingly, in all cases, there was still a substantial direct fire battle, with more than 100 kills by Apache, TOW, AGS, and Javelin.



Looking in more detail at the RFPI RSTA case with remote fires, we find that target kills took place much earlier and more completely than with base DRB. The long-range weapon accounted for half the total Blue kills. Nevertheless, 68% of the Red attacking force survived to engage in the direct fire battle. This may have been largely a function of the limited depth allowed for long-range attack in this scenario. Interestingly, Blue survivability was only slightly higher than with the base DRB. This suggests that added organic weapon systems or more effective long-range fires appear to be needed to reduce the direct fire intensity.



This chart highlights the problem. Even with substantial target acquisition in the RFPI RSTA case, only a small percentage of Red systems were engaged and destroyed by the long-range missile system. We next answer why this occurred.

Five Reasons Why Target Kills Did Not Match Target Acquisitions

(Using standard tactics, techniques, and procedures)

- **Acquisitions include small groupings (possibly ones and twos) of targets—inappropriate for weapon**
- **Requirement for battle damage assessment (BDA)—reacquired targets were not serviced immediately**
- **Engagements occur well after target acquisitions—many weapons missed intended targets**
- **Targets not individually serviced—within a volley submunition logic resulted in "high-signature" targets and hulks being reattacked**
- **Targets become more sparse and spread out over time—much harder to engage successfully**

We determined five reasons why long-range target kills were so much lower than the number of long-range acquisitions. First, many of the targets were spotted in groups of one to three—smaller groupings than required for calls for fire, even when the same targets were seen repeatedly. Second, there was a refractory period during missile flyout, in which the commander would have to wait for BDA on the targets before firing more missiles. Third, most targets were moving and would often turn at road junctions or transition into spread battle formations. This resulted in some misses with the 10-minute TOT. Fourth, the submunitions followed a group logic, in which they would distribute themselves among the targets. This logic was imperfect and often concentrated the submunitions toward high-signature targets, resulting in overkills. Finally, as the engagement ensued, targets became attrited and spread out, resulting in more difficult targeting and submunition encounter. In general, we noted the third and fourth reasons to be moderately important in this scenario, and the others to have somewhat lesser impacts.

Findings

- What kinds of opportunities do different RSTA concepts provide?
- How do different levels of target acquisition affect long-range weapon performance?
- **Given best RSTA, can external long-range weapons defeat armor attack, or will units need organic capability?**
- How does dispersion affect indirect and direct fire engagement dynamics?

- Ground-based RSTA gives accurate but limited coverage, overhead systems complete the picture
- More RSTA resulted in better long-range weapon effectiveness, but only up to a point
- **Aggressive use of external long-range weapons resulted in diminishing marginal returns; organic capability appears essential**

An important question was whether external, long-range fires alone could stop the enemy attack. Accordingly, we assumed near-perfect RSTA (all systems including HAE UAV) and examined the effectiveness of two different long-range weapon systems: large-footprint missile-delivered submunitions and air-delivered small-footprint submunitions. In order to look at many factors, a subset of the LANTCOM scenario was examined, and all runs were made with our smart munition model (MADAM) running in stand-alone mode. Interesting cases from this stand-alone parametric analysis were then examined in the larger force-on-force context in the Janus simulation.

We selected a portion of the Red attack—the south attack in column formation along the roads—for our first look at the two indirect fire weapons. Here two columns of armored vehicles (tanks, APCs, AD vehicles, and artillery) are moving along the roads. They cross several chokepoints at the river crossings and fan out into battle formations at the end of the time window examined. An active duty U.S. Army artillery officer conducted the fire missions against the vehicles as they were acquired by the RSTA network along the roads.

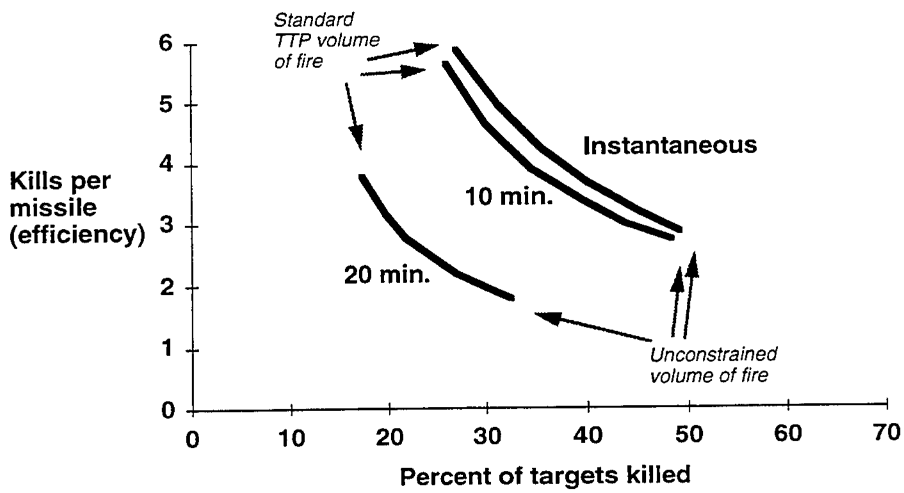
Sensitivity of Three Key Parameters Were Explored

- **Total time over target (intel processing, C3, and flyout)**
  - Instantaneous
  - 10-minute
  - 20-minute
- **Volume of fires (number of munitions employed)**
  - Conservative criteria for engagement based on TTPs
  - Aggressive engagement, increased volume of fires
  - Attack unconstrained with very high volume of fires
- **Density, shape, and predictability of target set**
  - Dense on-road column formations
  - Sparse off-road battle formations (not yet completed)

Assuming the best RSTA case, we varied three parameters in our excursions with the two long-range weapon systems. First, we set the timelines to be instantaneous (this can be thought of as immediate C2 and a very fast flyout, or as updating right over the target; it results in zero delay in the stand-alone analysis and a one-minute delay in the force-on-force simulation, for munition drop), and 10- and 20-minute TOTs. The second factor was the volume of fires applied. A conservative criterion was one missile or one munition dispenser (canister) per aimpoint, while unconstrained fires typically had four times as many missiles or canisters launched (with additional aimpoints). The last factor was the type of target set. As yet we have only targeted the dense on-road target set and plan to move later to analysis involving the more difficult and sparse off-road target set.

Single Volley Attack with Large-Footprint Weapon Did Not Result in Total Destruction of Target Set

"Near-perfect intel," targets moving in column formation†



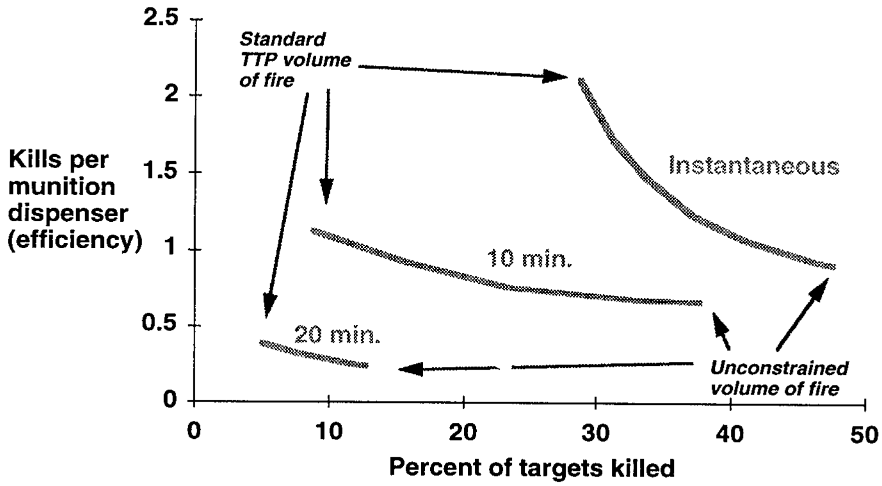
†Target lead was applied as appropriate; curves derived and smoothed from multiple simulation runs.

This chart shows results for the large-footprint submunitions delivered by missile. The y-axis is kills per missile, while the x-axis is scaled in percent of total targets killed. For example, on the x-axis a 50% score means that 44 of the 88 targets are killed. The lines for each TOT assumption (instantaneous, 10-minute, and 20-minute) show that diminishing numbers of targets are killed as the volume of fires goes up. In all cases, an increase in the number of missiles launched results in an increase in the total number of kills but substantially reduces the number of kills per missile. The lines also show that 10-minute TOT has almost the same efficiency as instantaneous, because the large-footprint submunition is able to make up for targeting errors induced during such short times.

It should be noted that the results shown above are for a single volley attack, without use of BDA and reattack of the targets later. Our Janus excursions showed somewhat greater effectiveness with multiple volley attacks using BDA.

Analysis of Small-Footprint Weapon Yielded Similar Overall Trend

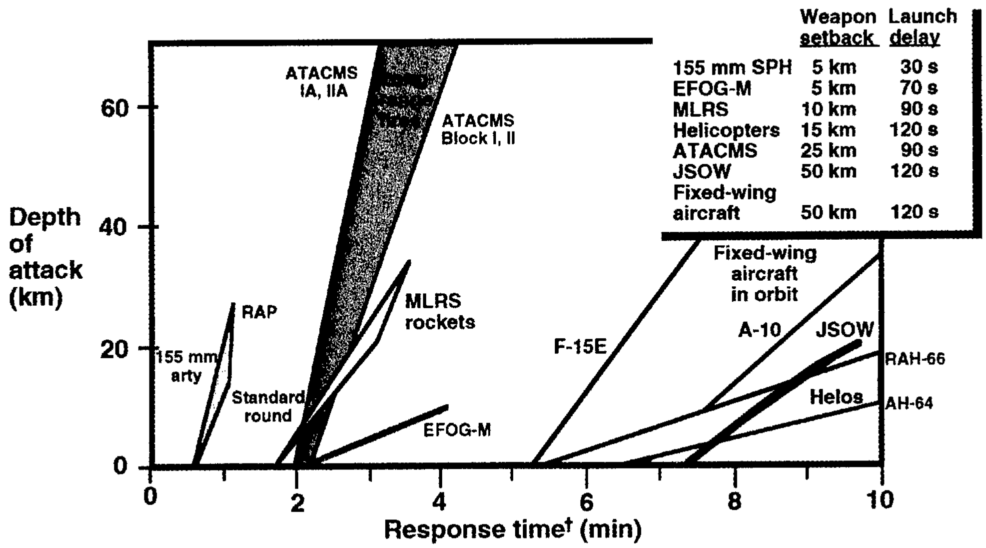
"Near-perfect intel," targets moving in column formation†



†Target lead was applied as appropriate; curves derived and smoothed from multiple simulation runs.

The smaller-footprint weapon showed markedly higher sensitivity to TOT, as one would expect. A 20-minute TOT yielded fractional kills per munition dispenser, because the target moved out of the footprint, even with lead applied to the targeting on a road. At 10-minute TOT, the weapon was more effective but still limited. Also, higher volumes of fire did not show the same level of saturation found with the large-footprint weapon. Nonetheless, a diminishing marginal returns effect was seen. Instantaneous delivery was highly effective with this system, yet still yielded no more than 50% kill of the total target set, even with very high volumes of fire.

Earlier Analysis Shows Time to Range for Different Weapon Systems/Platforms



†Does not include command and control delays, which are highly situation dependent.

To give some context for the TOT times discussed earlier, this chart illustrates expected times to range for a number of different systems. Missile systems (except for cruise missiles and EFOG-M) are much faster than aircraft and may arrive at the target after only a few minutes. Fixed-wing aircraft are typically orbiting some distance from the target and, depending on whether they overfly the target or release dispensers from standoff range, result in times on the order of 10 minutes or more. The chart above shows some representative TOTs based on approximated weapons setbacks and times to launch. The TOTs above do not include delays associated with command and control.

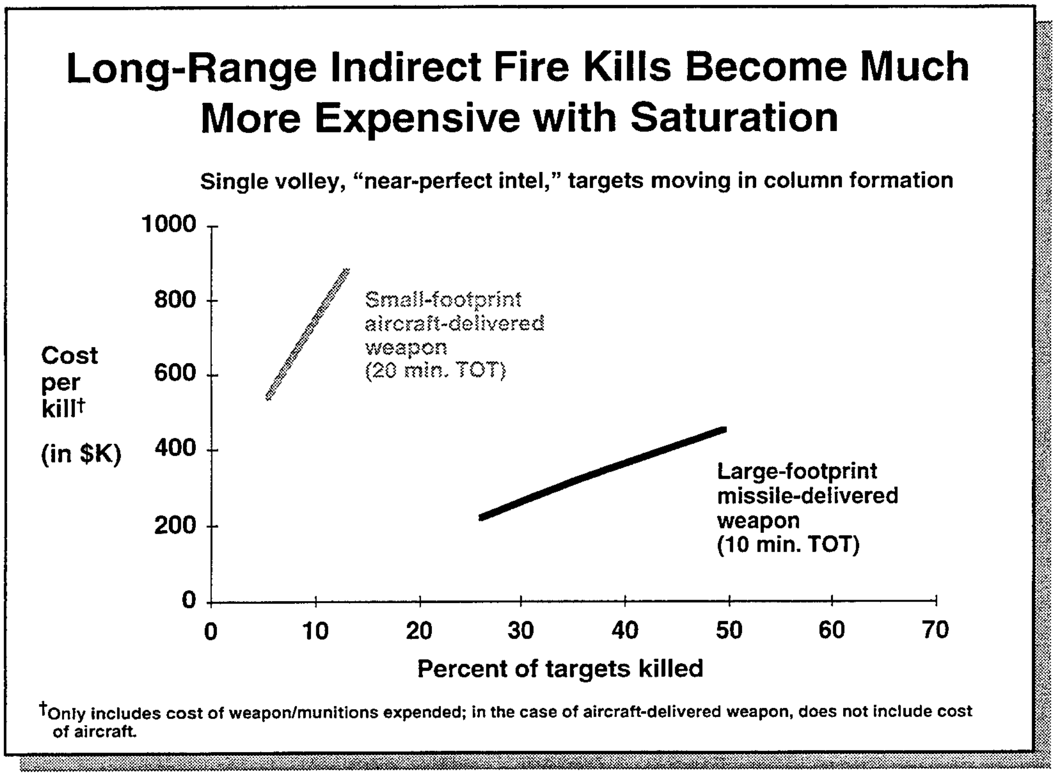
The meaningfulness of these timelines can change dramatically if there is update in flight. Then, sensitivity to target movement can be reduced; however, the long cycle time itself can present a "management of weapons flow" problem, especially if BDA is required before launching the next mission. To solve this problem, one may have to commit follow-on missiles or aircraft to attack before knowing whether the initial attack succeeds.

Weapon Cost Assumptions

(Back of the Envelope)

- **Large-footprint, missile-delivered weapon**
  - **Missile platform cost = $700K**
  - **Submunitions cost = $520K**
  - Total assumed cost = $1,220K
- **Small-footprint, aircraft-delivered weapon**
  - **Munition dispenser cost = $100K**
  - **Submunitions cost = $120K**
  - Total assumed cost = $220K

We felt it would be enlightening to perform a very rough, exemplary cost analysis for the two weapons used in these excursions. The costs shown are estimates for the two sets of delivery platforms and the submunitions they contain. The costs do not reflect development, support, or deployment costs, nor do they cover losses to the ground, sea, or air platforms that launch them. They are simply rough incremental cost numbers for the missiles, munitions dispensers, and submunitions themselves.



Extrapolating data from the previous charts (using nominal C2 and flyout times), it is possible to then estimate the cost per kill for different weapon alternatives. Assuming the small-footprint, aircraft-delivered weapon will take 20 minutes to achieve TOT, it is apparent that the corresponding number of misses of the target set translates to a relatively high cost per kill. As more munitions are fired at the target set, more targets are killed but with even less efficiency. However, very large payoffs were seen when instantaneous TOT was used in conjunction with this weapon.

On the other hand, the large-footprint, missile-delivered weapon resulted in relatively lower costs per kill because the combined TOT and size of footprint was a good "match" for the target set being attacked. Similar to the small-footprint weapon, though, as more of these munitions were fired at the target set, more targets were killed but with an increase in cost per kill.

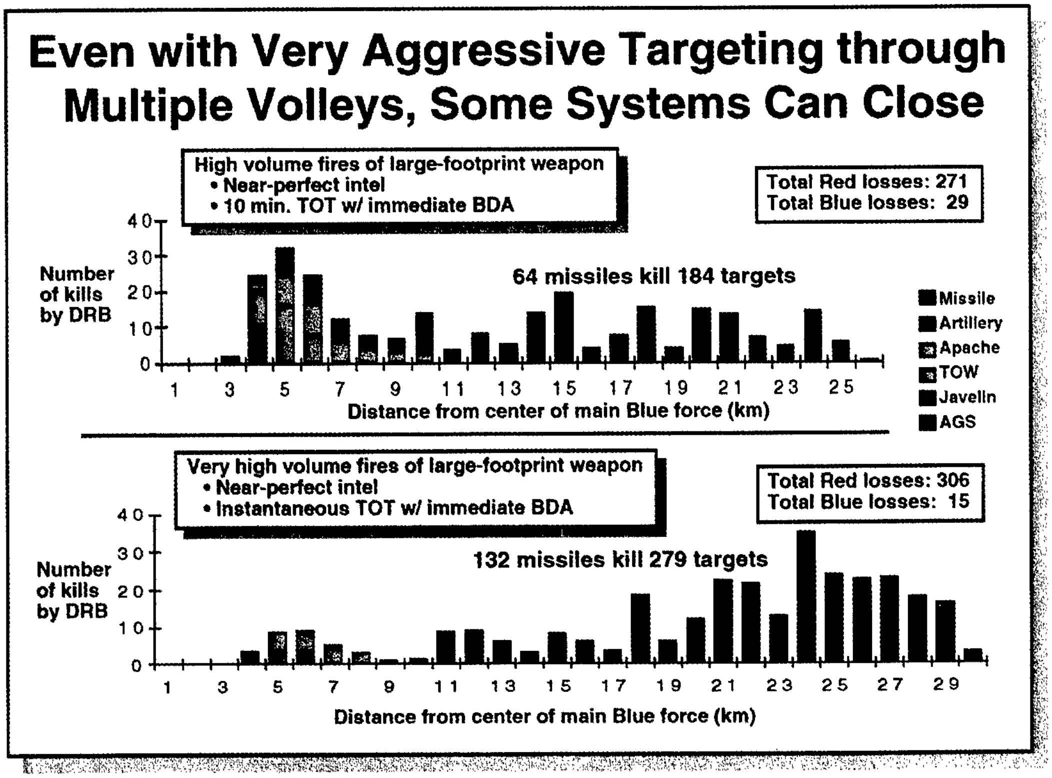
Both Increased Volume of Fires and Reduced Timelines Were Assessed in Simulation

- **Higher volume of fires**
  - **Resulted in more kills, but with less overall efficiency (kills per round) for both large- and small-footprint weapons**
  - **Resulted in many more rounds over friendly units for both large- and small-footprint weapons**
- **Improved time over target**
  - **Resulted in relatively minor effect on large-footprint weapon performance; about 10% increase in kills**
  - **Resulted in considerable performance improvement for small-footprint weapon; about 100% increase in kills**

We then extended the results obtained in MADAM by making excursions with the larger-scale Janus simulation. Here, we examined the impact of volume of fires and reduced timelines on the effectiveness of the large- and small-footprint weapons. The runs differed from those in MADAM in several ways: the entire threat force was engaged, multiple volleys were fired, and BDA was present. In all cases, near-perfect RSTA (ground sensors and HAE UAV) was assumed.

Volume of fires was varied by increasing the number of missiles or munition dispensers per aimpoint, and in some cases by adding more aimpoints. Just as with the MADAM runs, we found that higher volumes of fires led to decreasing marginal returns. We also noted that higher volumes of fires resulted in more rounds landing near friendly forces. No kills were seen, however, because the Blue vehicles were typically stationary, with limited signatures.

Improved TOT had very different effects with the two weapons, as seen in the stand-alone simulation. The large-footprint, missile-delivered weapon was able to compensate well for target movement during flyout, while the small-footprint, air-delivered weapon would often miss the moving targets when a time delay was present.



This chart illustrates the combined effect of volume of fires and TOT for the large-footprint weapon. The upper graph shows a volume of fires roughly twice that shown in the previous section, when standard TTPs were followed (see p. 23). We find that by roughly doubling the number of missiles, only 50% more kills could be achieved.

A major change is shown in the lower graph. Here we roughly quadruple the number of missiles and change the TOT to instantaneous. Long-range missile kills now occur farther out, attrit about 80% of the target set, and result in a very limited direct fire battle. This very favorable outcome comes only with exceptional conditions—near-perfect RSTA, instantaneous TOT, and very high volume of fires.

How Do External Long-Range Fires Integrate with Advanced Organic Indirect Fires

- **External fires (both large- and small-footprint) were more effective against targets at longer range**
  - **Target density was high—good match with multiple submunition weapon concepts**
  - **Target movement was highly predictable—more forgiving to longer timeline weapons**
- **Advanced organic indirect fires were seen to be effective against targets at closer range**
  - **Targets were sparse—tended to be individually and efficiently serviced**
  - **Targets moved tactically—short weapon timelines provided sufficient ability to react**

In ongoing studies for the Rapid Force Projection Initiative we have examined a wide variety of advanced organic indirect fire weapon systems, among them EFOG-M, HIMARS/Damocles, 155-SADARM, Smart-105, and PGMM.[2] This work highlights some of the apparent differences (and the complementary nature) of these organic systems with the external long-range fire systems being considered by the DSB.

Both of the external long-range fire systems we have considered are multiple submunition concepts designed to attack massed armor targets. They work well when the targets move in predictable patterns across roads and open areas, and are especially good at chokepoints.

The shorter-range organic systems, on the other hand, range from multiple submunition concepts to individually targeted missiles and artillery rounds. Many of these are able to attack individual targets moving from cover to cover with short opportunity windows. Some systems such as EFOG-M are also able to discriminate in flight between target types—live and dead, friendly and enemy, and high value and low value. Other weapons, such as HIMARS/Damocles, are effective at longer ranges in counterbattery fire.

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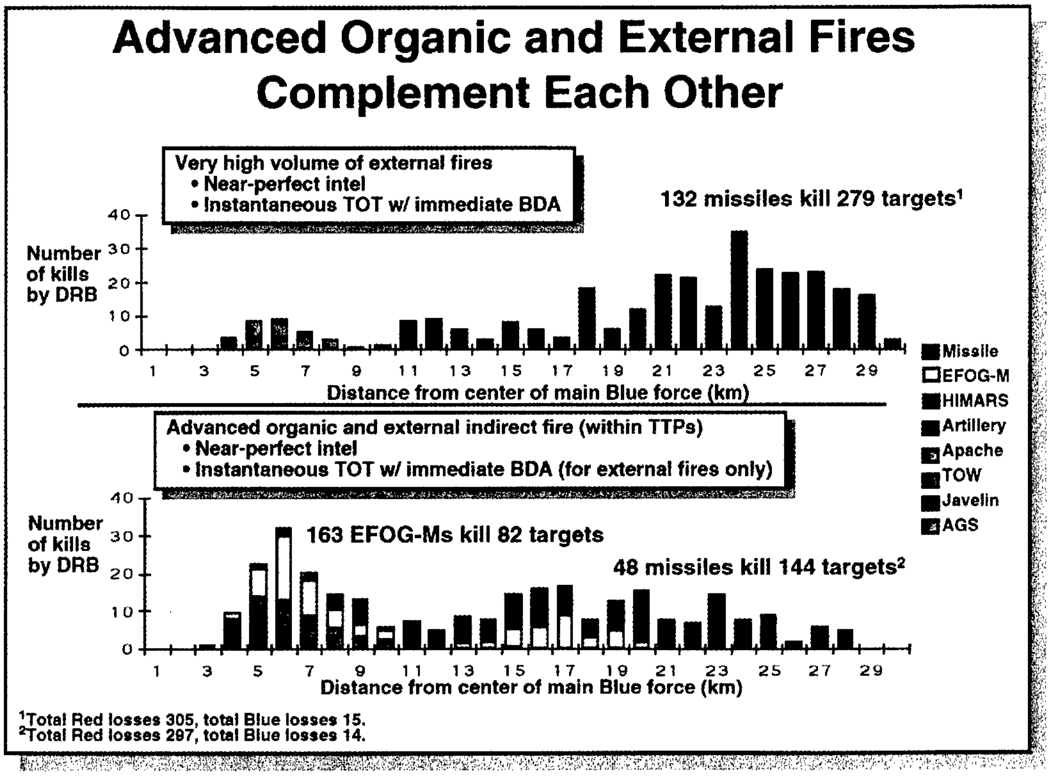
[2]For a detailed description and performance analysis of these systems, see R. Steeb, J. Matsumura et al., *Rapid Force Projection Technologies: A Quick Look Analysis of Advanced Light Indirect Fire Systems*, RAND, DB-169-A/OSD, 1996.



The above charts illustrate the differences between a very high volume external missile attack and a more balanced attack (using standard TTPs) employing both external and organic indirect fire. The very high volume missile attack results in large numbers of kills at deep ranges, but the ability to attrit (and level of efficiency) drops off at closer ranges—resulting in a small residual direct fire battle. In contrast, the more balanced attack, which uses standard TTPs, results in relatively moderate attrition at deep ranges, and many of the closer-in engagements are handled by more efficient organic indirect fires. High-value enemy artillery targets are targeted primarily by HIMARS/Damocles, while armor is primarily targeted by EFOG-M. The "shape" of the attrition is significantly different between the long-range external and combined external/organic cases, but the outcomes, in terms of direct fire battle intensity and overall LER, are quite similar.

In an additional excursion (not shown here), two less active systems, HMMWV-TOWs and AGS, were removed from the scenario. This resulted in the same overall lethality (number of Red systems killed), but reduced the Blue losses by 30%.

Findings

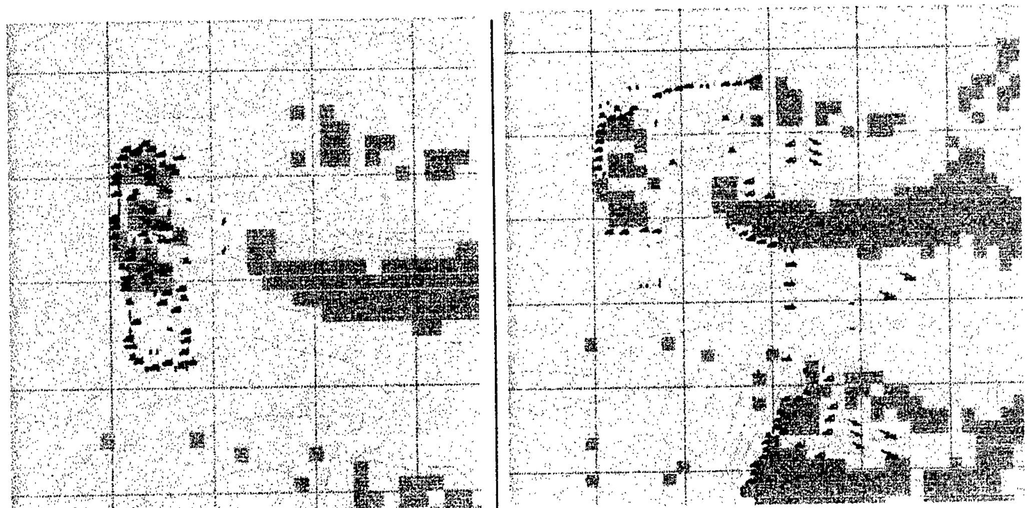
- What kinds of opportunities do different RSTA concepts provide?
- How do different levels of target acquisition affect long-range weapon performance?
- Given best RSTA, can external long-range weapons defeat armor attack, or will units need organic capability?
- **How does dispersion affect indirect and direct fire engagement dynamics?**

- Ground-based RSTA gives accurate but limited coverage, overhead systems complete the picture
- More RSTA resulted in better long-range weapon effectiveness, but only up to a point
- Aggressive use of external long-range weapons resulted in diminishing marginal returns; organic capability appears essential
- **Dispersion reduces base DRB losses to artillery but direct fire battle is compromised**

The last question involves dispersion of the force. With the base DRB, we found that a rough, first level of dispersion resulted in decreased losses to enemy artillery, as one would expect. At the same time, the larger defended perimeter resulted in a more heated direct fire battle and easier Red penetration.

In a similar vein, we looked at a first level of dispersion of the Red force. This resulted in a moderate reduction of effectiveness of Blue long-range fires.

Some Level of DRB Dispersion Was Examined in this Research

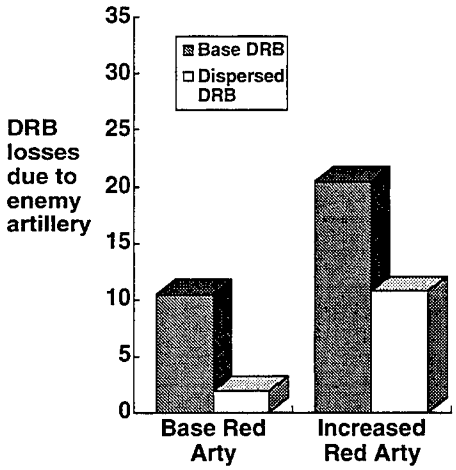


Current DRB has tight formation | Dispersed DRB is broken into Bns

The actual level of dispersion is shown graphically above. The original Blue DRB laydown involved a laydown on a dominant hill mass approximately 4 km long and 2 km across. Dispersion of the force kept one battalion on the hill mass, and the second battalion on high ground to the south. Interlocking, supporting fires were still possible between the battalions, but the area covered by the force expanded by 5 to 6 times compared to the original formation. Red also modified its attack against the dispersed force, shifting its thrusts and massing its fires against new areas.

The dispersion illustrated represents a simplistic first level of spreading the force. We plan to examine more sophisticated laydowns in future work.

Dispersing DRB Can Reduce Losses from Enemy Artillery Fire...



- With baseline Red artillery levels, about one-third of DRB losses can be attributed to artillery
- With increased enemy artillery levels, over half of DRB losses are due to enemy artillery

=> Fight can be lost before it even starts

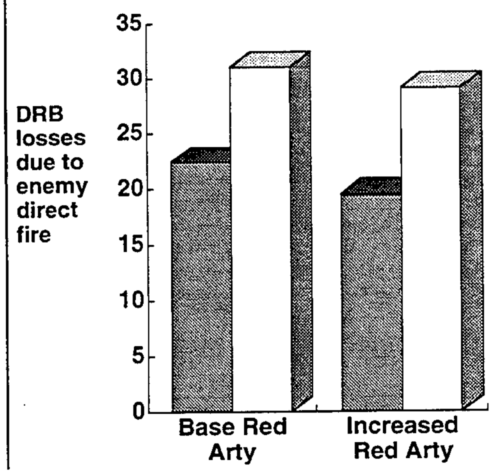
- Dispersion can provide a means to minimize the effectiveness of Red artillery fire

We found that dispersion of the Blue force did in fact reduce losses to enemy artillery. The dispersion effect was greater with the moderate level of artillery found in the basic scenario than when artillery was increased to higher levels (36 SP-152mms instead of 12 in the basic complement; 90 total Red artillery systems instead of 18 originally).

However, Dispersion Can Compromise the Direct Fire Battle

- Larger defensive perimeter increases exposure of DRB force
- Red can attack with greater simultaneity (fewer echelons)
- As a result, local Red direct fire weapon ratios are higher and more DRB losses occur

=> Early advantage from dispersion can be negated by the close fight



The picture changed dramatically in the direct fire battle. Regardless of Red artillery level, the dispersed force suffered more direct fire losses and achieved a lower overall LER than the nondispersed forces. This appeared to be because the larger perimeter resulted in less efficient overlapping fields of acquisition and fire for Blue and permitted more efficient simultaneous application of Red firepower. Red was able to more effectively mass fires and penetrate the thinner Blue perimeter.

What Happens If Red Disperses?

As a first step, Red battalion-column advance was broken up into company-sized targets

(Assuming near-perfect intel and very high volume of fire)

- **Fewer total missiles were fired by Blue (25%)**
- **Attrition started somewhat closer (3 km)**
- **Total long-range fire kills went down (15%)**
- **Nonetheless, efficiency per missile increased (10%)**
  - **Lower ratio of missiles to target; less competition for targets**
  - **Advanced submunition logic distributed submunitions with less overlap, resulting in fewer overkills**

Red has many options to counter the effects of long-range fires. One of the most fundamental of these is to disperse. We examined a first step in this direction, by breaking up the battalion units along the roads into company-sized ones, with commensurate spacing down the echelons. The force was then more spread out and targeting was more difficult—missiles were fired later, fewer launches were made, and total kills were reduced. The effect would have been even greater, but the dispersed target spacing was in many places a better match with the large-footprint weapon's spread logic than the nondispersed target set, resulting in fewer overkills and misses. Further spacing may not exhibit this behavior.

Our Simulation Environment

- Basic scale constraints: size of region, terrain resolution, time step, and number of entities
- Fog of war: pace does not reflect friction, miscues, and human error
- Combat operations: still difficult to assess operational maneuver, MOUT environment, SOF/ dismount movements, large air operations
- Threat behavior: as Blue force changes shape, threat will likely change shape as well

A series of caveats must be stated with respect to our simulation environment, as with most others. The Janus-based system is intended for system-on-system warfare at the brigade/division level, and it provides only limited applicability outside that region. The system assumes prepared, motivated forces on both sides, and does not account for the "fog of war." We are in the process of extending the environment to include other missions, such as MOUT and SOF, but these are not yet in place. Finally, we assume the threat will remain as a maneuvering armor force, regardless of the Blue composition. If Blue was composed of small dismounted and dispersed teams calling in long-range fires, Red would probably instead counter with infantry operations and dispersion of its own.

5. CONCLUSIONS

Outline

- Background
- Research plan
- Findings
- Conclusions

This section summarizes our observations from this research.

Conclusions
(LANTCOM Scenario)

- **Enhancing DRB with external RSTA and fire support has tremendous potential for improving outcome of battle; however:**
  - **Even with multi-tiered RSTA, some portion of attacking target set was not acquired**
  - **Given best RSTA case, advanced weapon systems examined did not provide comprehensive lethality at range**
  - **Impact of long-range attack can be reduced by deliberate threat actions**
- **Given the above, DRB should be prepared to fight close battle—to achieve objective**

In general, the DSB concept for enhancing small dispersed forces with external RSTA and weapons offers tremendous potential for improving the outcome of battle. However, we note the concept relies on many steps to operate effectively—acquiring targets, passing information, assigning weapons, dispensing munitions, performing BDA, and many others. Each of these steps must function well for the concept to succeed.

Up to a point, we found that adding layers of ground-based and overhead RSTA could significantly improve situational awareness and enhance the application of external fires. The situation estimate can seldom be both complete and accurate, though, and different types of sensors contribute different inputs to the overall picture. In those cases where overlap of coverage was present, additional value was still observed in the form of commander confidence in committing rounds.

The notion of "if you can see it, you can kill it" was not demonstrated here. External fire support may exhibit long flyout and cycle times, and may not be able to engage targets as decisively as organic weapons. This can be especially true if the enemy uses deliberate countermeasures.

In view of such uncertainties, a force equipped with organic firepower appears to be essential, especially so when either an objective must be protected or an area denied to the enemy. Although our research does suggest that the amount of organic capability can be reduced given a significant presence of effective external RSTA and fire support, the most attractive and robust solution for enhancing the capability of small forces was a mix between advanced organic systems *and* external systems.

What Technologies Can Help Maximize Viability of the Concept?

What can go wrong with the concept and what do we need to make it work?

- **Environment might not cooperate (e.g., jungle, urban, etc.)—need all-weather, multi-mode sensors and weapons**
- **Connectivity is not guaranteed (e.g., terrain, portable jammers, etc.)—need robust, reconfigurable architectures**
- **Countermeasures can proliferate (e.g., corner reflectors, towed decoys, obscurants, etc.)—need discriminating, intelligent systems with ability to fuse multi-mode information**

The DSB concept is an ambitious one—equipping a small force to be able to carry out a wide range of missions normally performed by much larger forces. In order to ensure the viability of the concept, it must be made robust to many different influences and conditions of the environment, responses by the enemy, and even pressures of our own organizational structures. As a start, multi-mode sensors and long-range weapons with seekers may have to be modified heavily to operate in different environments. They may be stymied completely by urban environments, triple canopy jungle, monsoons, or sandstorms. Some mix of all-weather multi-spectral sensor sets, data fusion centers, and long- and short-range weapons will undoubtedly be necessary to cover a reasonable range of conditions.

One of the more vulnerable assumptions in the concept is connectivity between the many components—RSTA, communication nodes, fire direction centers, and weapon platforms. Blockages, noise, occupancy levels, node losses, reconfiguration times and other phenomena have been modeled only to a cursory level in most simulations, and few field tests have explored the types of systems being considered. Highly redundant, yet low probability of intercept architectures must be designed and demonstrated.

Enemy countermeasures, finally, cover a wide range of possible tactics and technologies. These may include attacking RSTA systems, camouflaging vehicles, spoofing sensors, disabling C2 networks, or defeating incoming munitions. As countermeasures become more sophisticated, sensors, seekers, and other components will have to become more intelligent and timelines will have to be minimized.

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